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# THE ABILITY TO PLACE THE DECIMAL POINT IN DIVISION

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A number of investigators have given data to show that "ability" in arithmetic consists of several specific abilities rather than a single ability. It has been stated that there are as many different abilities as there are different types of examples. The purpose of this study was to analyze the ability to place the decimal point in the division of decimal fractions.

The method of study was to construct a series of tests each of which called for the placing of the decimal point in slightly different types of examples. Since it was desired to test merely the ability to place the decimal point, the answers were given with the exception of placing the decimal point, as shown in the test which is reproduced below. Test I<sup>1</sup> is reproduced to illustrate the type of

## DECIMAL TEST I

The correct answer for each example is given at the side immediately after the letters "Ans." Write it in its proper position and place the decimal point in its proper place.

3 ) <u>16.2</u>	Ans.: 54	7 ) <u>1.82</u>	Ans.: 26	5 ) <u>.415</u>	Ans.: .83
6 ) <u>7.44</u>	Ans.: 124	8 ) <u>.952</u>	Ans.: 119	4 ) <u>87.6</u>	Ans.: 219
2 ) <u>.144</u>	Ans.: 72	8 ) <u>40.8</u>	Ans.: 51	9 ) <u>3.42</u>	Ans.: 38
3 ) <u>47.4</u>	Ans.: 158	7 ) <u>8.61</u>	Ans.: 123	5 ) <u>.965</u>	Ans.: 193
9 ) <u>5.76</u>	Ans.: .64	4 ) <u>.348</u>	Ans.: 87	6 ) <u>51.0</u>	Ans.: 85
2 ) <u>.748</u>	Ans.: 374	3 ) <u>89.1</u>	Ans.: 297	5 ) <u>6.85</u>	Ans.: 137

Name.....Grade.....Date.....

<sup>1</sup>A series of tests upon decimal fractions similar to these can be obtained from the writer.

tests and the form in which they were given to the pupils. In Test I, the divisor is an integer in no case greater than nine. The dividends are of three types. The examples are arranged in the test so that the different types of examples recur in regular cycles. Test II is of the same general type as Test I with the exception that the divisors are all tenths. Test III was constructed identical with Test I except that the divisors were hundredths instead of integers. Test IV is a composite test involving a number of different types of examples in long division.

These tests were given to three groups of pupils by an advanced student<sup>1</sup> working under the direction of the writer. This student had had considerable experience in giving tests. The pupils also had been given the Courtis Standard Research Tests, Series B, the previous year. A mimeographed copy of the test was given to each pupil. The time allowance for each test was one minute. In the sixth grade the four tests were given in immediate sequence. In the seventh and eighth grades the first two tests were given in immediate sequence and two weeks later Tests III and IV were given in immediate sequence.

In order to provide a check upon the data secured by the first giving of the tests, Test I was given about five months later to the pupils of the sixth grade on three successive weeks. The tests were given without previous knowledge by either the teacher or the pupils. At the same time Test II was given in the same way to the seventh-grade pupils and Test III to the eighth-grade pupils.

A pupil's performance depends upon several factors of which his ability is one. His performance is influenced by his physical condition, his mental and emotional status, the physical condition of the room, and particularly the way in which the tests are presented to him by the examiner. Thus, in order to be able to infer from the performances of a pupil whether the ability which functions in two different situations is a single general ability or two specific abilities, it is necessary to have the other factors which affect his performance as nearly constant as possible. In this investigation the same examiner gave the tests, and care was taken to have the other

<sup>1</sup> The writer is indebted to Mr. Harry McGuire, now superintendent of schools at Kiowa, Kansas, for giving the tests and making the calculations.

factors as constant as possible. Thus if the individual pupils made approximately the same relative scores on each of the tests, the evidence will indicate that the same ability functioned in all tests. On the other hand, if there are large differences in the two sets of scores, there will be evidence that the ability which functioned in one test was not the same ability that functioned in the other test. In order to show the relation between scores of the several tests,

TABLE I  
SEVENTH-GRADE ATTEMPTS, DECIMAL TESTS I AND III

																	Test III	Frq.		
																	18	.....		
																	17	.....		
		I					I										16	2		
										I							15	1		
																	14	.....		
						I											13	1		
																	12	.....		
		I												I	I		11	3		
																	10	1		
						I											9	1		
		I				I						I					8	3		
			I					I						I			7	3		
				I					I						I		6	3		
		I									I	I					5	3		
																	4	.....		
																	3	.....		
																	2	.....		
																	1	.....		
																	0	.....		
Test I.....	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	.....
Frq.....	3	2	..	1	2	1	3	1	..	1	2	1	2	2	..	..	..	..	..	.....

they were paired in every possible way for each group of pupils and the scores for each pair of tests were tabulated for both the number of examples attempted and the number right, as shown in Table I. Thus Table I shows the number of examples attempted by twenty-one seventh-grade pupils in Tests I and III. The scale at the right of the table is for Test III and the scale at the bottom is for Test I. The table is read as follows: Two pupils attempted sixteen examples on Test III; one of these pupils attempted seventeen examples on Test I, and the other only twelve examples. One pupil attempted fifteen examples on Test III and only nine on Test I. One pupil

attempted thirteen on Test III and thirteen on Test I. Three pupils attempted eleven examples on Test III. Their scores on Test I were 18, 6, and 5.

In order to summarize the facts shown in the thirty-six tabulations of the type shown in Table I, the coefficient of correlation was calculated by the Pearson formula. The coefficient of correlation

TABLE II  
COEFFICIENTS OF CORRELATION FOR ATTEMPTS

	Grade VI 34 Pupils	Grade VII 22 Pupils	Grade VIII 22 Pupils
Test I with Test II.....	.41	.27	.48
Test I with Test III.....	.55	.07	.06
Test I with Test IV.....	.31	.15	.15
Test II with Test III.....	.44	.16	.40
Test II with Test IV.....	.39	.46	.45
Test III with Test IV.....	.58	.38	.68
Average.....	.45	.25	.37

TABLE III  
COEFFICIENTS OF CORRELATION FOR RIGHTS

	Grade VI 34 Pupils	Grade VII 22 Pupils	Grade VIII 22 Pupils
Test I with Test II.....	.06	.06	.44
Test I with Test III.....	.39	.37	.42
Test I with Test IV.....	.14	.29	.36
Test II with Test III.....	.66	.54	.58
Test II with Test IV.....	.47	.66	.80
Test III with Test IV.....	.52	.64	.68
Average.....	.37	.41	.55

necessarily represents a broad generalization and for this reason conceals the particular facts, but it does make possible a general bird's-eye view of a large group of facts of this sort. The coefficients of correlation are given in Tables II and III.<sup>1</sup> For each group of pupils the coefficients of correlation have been averaged. These averages have no particular significance except that they assist in

<sup>1</sup> The coefficients of correlation have not been corrected and the P.E. is not given. These were calculated for several of the coefficients and were found to be relatively small.

securing a general view of the several coefficients contained in the tables.

With one exception the coefficients are all positive and in many cases are large enough to indicate a reasonably high degree of positive high correlation. A fair degree of positive correlation should be expected even if two separate and distinct abilities are required for examples of different types, because pupils may possess both abilities in the same degree; in fact, we must expect this to be true in a large number of cases because the training has been general and not directed upon any one type of examples included in this test to the exclusion of other types. On the other hand, it must be kept in mind that any variation in the several factors upon which the performances of the pupil depend will produce variation in the scores and hence tend to lower the degree of correlation.

Bearing in mind these two facts, we should not expect a coefficient of correlation approaching 1.00 and likewise we should not expect negative coefficients or coefficients very close to zero. The significance of the variability of the scores shown in the tabulation tables, of which Table I is an example, and also the significance of the generalized data given in Tables II and III can only be interpreted by comparison with the similar data which was obtained by repeating the tests on three successive weeks. The scores thus obtained were tabulated in the same way and the coefficients of correlation are given in Tables IV and V. By giving the tests a week apart, it is probable that the degree of uniformity of the factors which governed the performances of the pupils was less than in the first giving of the tests. If this was the case, the tendency would be to reduce the coefficient of correlation in Tables IV and V.

Comparing Tables II and III with Tables IV and V we find that in general the coefficients of correlation in Tables II and III are much lower than the coefficients of correlation in Tables IV and V. The difference is probably sufficiently great to indicate that for these pupils, at least, placing the decimal point was accomplished by means of specific abilities. This suggestion is emphasized by a study of the detail facts given in the tabulations of the scores. A few pupils made relatively the same scores on all the tests. There were a few cases of extreme variation which probably could be

explained by some unknown variation in the factors attending the giving of the tests. The fact that some pupils made relatively the same score upon two different tests does not constitute positive evidence that the examples were done by means of a general ability. It may be that it simply happened that these pupils possessed the specific abilities required in the same degree.

The writer gave these tests to a group of adults and afterward secured their introspection of their processes in placing the decimal

TABLE IV  
COEFFICIENTS OF CORRELATION FOR ATTEMPTS

	Grade VI Test I	Grade VII Test II	Grade VIII Test III
First record with second.....	.75	.71	.35
First record with third.....	.55	.68	.34
Second record with third.....	.86	.80	.80
Average.....	.72	.73	.49

TABLE V  
COEFFICIENTS OF CORRELATION FOR RIGHTS

	Grade VI Test I	Grade VII Test II	Grade VIII Test III
First record with second.....	.72	.62	.55
First record with third.....	.48	.58	.72
Second record with third.....	.84	.66	.86
Average.....	.66	.62	.71

point in each type of example. These introspections showed very clearly that a variety of devices were used and that the same person used different devices in placing the decimal point in different types of examples.

The number of pupils involved in this study is too small to warrant even tentative conclusions if other studies had not been made with other types of examples. In view of the results of other studies, one is probably justified in concluding that the decimal point is not placed in quotients by means of a general rule or general ability, but by means of several specific abilities, or at least that this is the case with a number of pupils.

Assuming the possibility of this conclusion, a little consideration will reveal that there are a large number of types of examples in division of decimal fractions. Even within a range of relatively simple examples it is possible to enumerate a considerable number of types. If each type of example requires a specific ability, it is clearly very important that this field of subject-matter be carefully analyzed to determine the fundamental types of examples. It is also obvious that it is extremely important that each teacher be aware of the several types of examples which exist, and make certain that each pupil is trained in handling each type of example. Without a reliable analysis of this field of subject-matter and without the teacher being aware of the fundamental types of examples, her instruction cannot fail to be largely a matter of chance.

Tests should be given for the purpose of securing information which can be used in making the instruction more effective. Tests which are not based upon analysis of the field of subject-matter cannot be effective instruments for educational diagnosis. Their use can have little value except to provide a very general measure of the abilities of the pupils. On the other hand, tests based on the scientific analysis of abilities can provide a very valuable diagnosis which can be very helpful to the teacher in formulating her plans for instruction. If a pupil is shown to be unable to do with satisfactory speed and accuracy examples of a given type, the teacher may know that this defect must be remedied by providing some special training for this pupil. For this reason teachers and superintendents should exercise judgment in selecting tests, and should choose those which will be most helpful to teachers in increasing the effectiveness of their instruction.